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"Towards Enchancement of Agriculture and Animal Husbandry, Natural Resources and the Environment, and Engineering in the ASEAN"

September 10 -11- 2018
Malang, Indonesia

Held on Cooperation between :

University of Islam Malang (Faculty of Agriculture, Animal Husbandry, Mathematic and Science, and Engineering) and some abroad Universities.

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IMPROVEMENT OF FARMER HARVESTING RESULTS BY THE OPTIMIZATION MODEL OF MICROCONTROLLER BASED IRRIGATION

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ABSTRACT

In order to solve the problem of food resilience trough eco-friendly technology innovation, one of them is by increasing the harvesting result trough optimizing the distribution and efficiency of irrigation water supply. Water distribution in irrigation becomes a problem since the distribution plan did not suitable with the requirement where in the past few years in Indonesia there was a water shortage in the dry season which has resulted in a lack profit in agricultural land. Refer to the water resource management research, there are many factors that influence the provision of water into irrigation area, one of the problems is improper planning of water irrigation distribution for the cropping patterns. The purpose of this study was to obtain an optimization model of irrigation water distribution and new technology utilize to streamline the distribution of water into irrigation areas. This optimization model including in the rainy and dry seasons in a period of planting season in order to increase yields to support rice self-sufficiency. This research was design the prototype of an irrigation channel and irrigation sluice gate which operate automatically by applying microcontroller technology. The operation of the irrigation sluice gate was adjusted to the optimization model of irrigation water distribution data, where in this case varied by 0.5; 0.8; 1; 1.5; 2; 2.5; 2.8; 3 and 3.5 cm. These prototype was successfully simulate the automatic sluice gate operation and describe the water flow characteristic in an open channel flow.

Keywords*: irrigation, sluice gate, microcontroller.*

1. Introduction

Food is a basic human need and agriculture is one of the vital sectors to provide it. Food requirement increases as population growth in a country, including in Indonesia. In order to support the national food security program, rice self-sufficiency, economic capacity improvement and community welfare, an efforts need to be made to increase farmer's crop yields. The increments of food requirements in some case unbalanced with the availability of irrigation water. The farmers face the three major problem regarding the availability of irrigation water, namely: (1) saving the water use (2) increasing the water productivity; and (3) increasing rice production with limited amount of water (Bouman *et. al.*, 2007). The water management treatment affect to the plant height, number of seedling plants and crop yields (Devi, 2010). Optimizing the use of irrigation water requires a proper and planned management (Yulia, 2012).

As a substantial element in harvest production, the water requirement is determined by several factors such as soil type, soil fertility, climate (wet or dry), planting period, plant varieties, etc. A Large water requirement usually needed during planting rice, starting when preparing the land until it enters the pregnancy phase of rice (Juliardi and Ruskandar, 2006). In 2006, the rice field's area in Indonesia reached 8.9 million hectares, with irrigated rice fields covering an area of 6.7 million hectares. From the total irrigated rice fields, 5.2 million hectares are in good condition, while the rest are damaged (BPS, 2007).

In order to solve the problem of adequate and efficient water availability on agricultural land, the development of water supply model is necessary to be implemented. The water supply model will implemented by optimizing the distribution and efficiency of irrigation water provision in Irrigation Areas (DI). One of affecting factor in water provision is planning to determine the

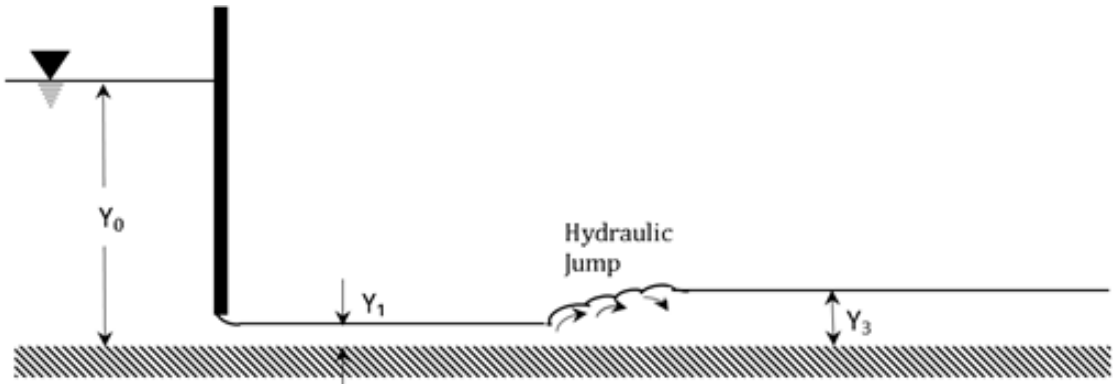
cropping pattern and distribution of irrigation water. An appropriate water delivery models and cropping patterns, may optimize the distribution of irrigation water to the farm land.

Finding the prototype of microcontroller-based irrigation water distribution equipment is the most likely technology to improve the irrigation water distribution. An efficient Irrigation is a solution which expected to increase the added value of the harvest or crops yield.

An Open Channel Irrigation

An irrigation channel mostly be in the form of an open channel flow. When a vertical sluice gates applied to an irrigation channel, there are various characteristic of channel flow. A hydraulic jump is defined as a rise in the level of water in an open channel, it is come about a liquid at a high velocity discharges into a zone that has a lower velocity. A sudden transition from a supercritical open channel flow regime to a subcritical flow motion will create hydraulic jump phenomenon (Murzyn and Chanson, 2009). Figure 1 represent the hydraulic jump phenomenon in an open irrigation channel.

Figure 1.1 Hydraulic Jump Phenomenon in an open irrigation channel with vertical sluice gate.



Where,

Y_0 = Entrance Depth

Y_1 = Upstream Water Depth

Y_3 = Downstream Water Depth

A dimensionless number which directly gives the ratio of current velocity v to the velocity of gravity waves in a current of depth D is known as the Froude number (Baines, 1995). The Froude number (Fr) is define by:

$$\mathrm{Fr} = \frac{V}{\sqrt{g\ x\ D}}$$

Where,

v = flow velocity (m/s)

g = gravity acceleration (m/s2)

D = Hydraulic depth (m)

The Froude number *(Fr)* used to determine the resistance of a partially submerged object moving through water, where $F_r < 1$ are called subcritical and $F_r > 1$ are called supercritical. Subcritical flow *Fr* occur at the time when a disturbance may propagate upstream, and supercritical flow *Fr* come about a disturbance is swept downstream.

2. Material and Methods

This research use an experimental methods by designing a prototype of automatic irrigation gates as a model and applied it at irrigation channel in laboratory.

Irrigation Channel and Gate

Irrigation channel modeled as a rectangular flatbed channel with below dimension:

Channel length : 820 cm

Channel width : 16 cm

Channel height : 29 cm

The Sluice gate was made of aluminum sheet which strengthened by ferrous metal. The power are transmitted from stepper motor by bevel gear to change the motor rotation into vertical sluice gates movements.

Automatic Control System

An automatic irrigation gates was controlled by a system which contain of:

- Arduino Uno, as a microcontroller board
- HC-SR04 ultrasonic sensor, as e water height sensor
- Stepper motor and stepper motor driver (TB-6560)
- Power Supply 12 V ⎓ 5 A

In these research, the prototype of microcontroller-based irrigation water distribution equipment used to determine the water flow characteristic such as flow rate and velocity due to the sluice gate opening. The sluice gate opening are varied as 9 types (0.5; 0.8; 1; 1.5; 2; 2.5; 2.8; 3 and 3.5 cm). The opening gate value are decide by analyzing the condition of water sources and water requirements in the wet and dry seasons furthermore optimizing the cropping pattern in the actual conditions. The Water flow characteristic was measured at three different area (entrance, discharge and downstream area)

3. Result and Discussion

The prototype of irrigation channel, automatic sluice gate and its control are shown at figure 3.1.

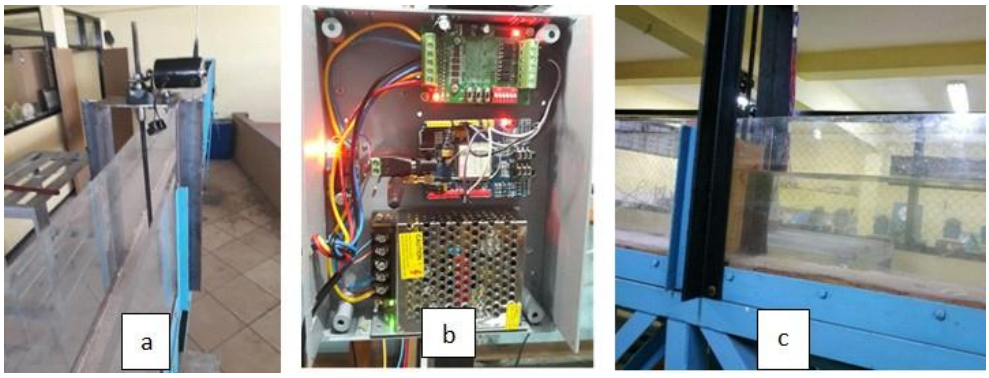


Figure 3.1 Prototype of sluice gate and irrigation channel. a) And Open channel and mechanical control, b) Automatic control system, c) water flow control by the opening of sluice gate.

Figure 3.2 denote the effect of sluice gate opening into the entrance water level. Control- ling entrance water level intend to confirm submerged sluice gate. The maximum entrance water level reach 25-27 cm minimum sluice gate opening, it is proves that the sluice gate design are cover the maximum entrance water level.

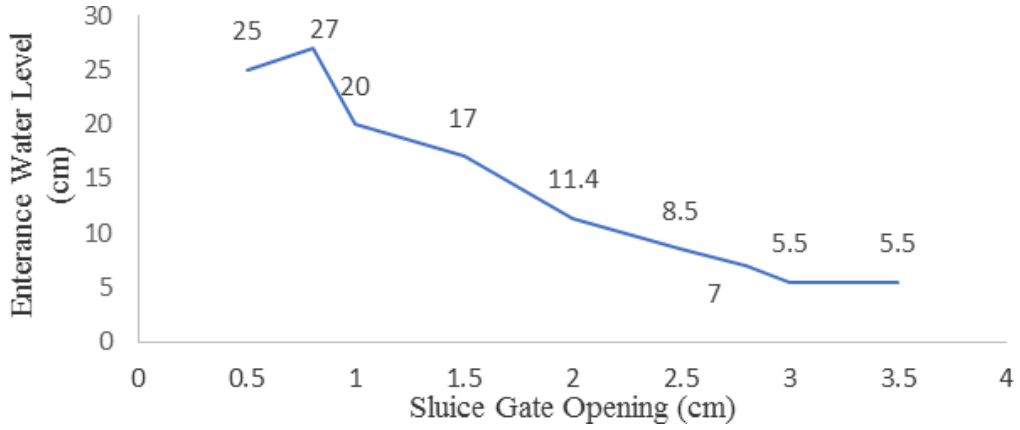


Figure 3.2 Effect of sluice Gate Opening on Entrance Water Level

The measurement of flow rate at different sluice gate opening, are shown on figure 3.3. The flow rate was increase with the increments of sluice gate opening, which variate 0.5 – 3.5 cm. Theoretically, when the sluice gate opening increase, the cross section area of water flow will be increasing which made flow rate increment. The maximum flow rate 3266.5 m^3/s, was reach at 3.5 cm sluice gate opening.

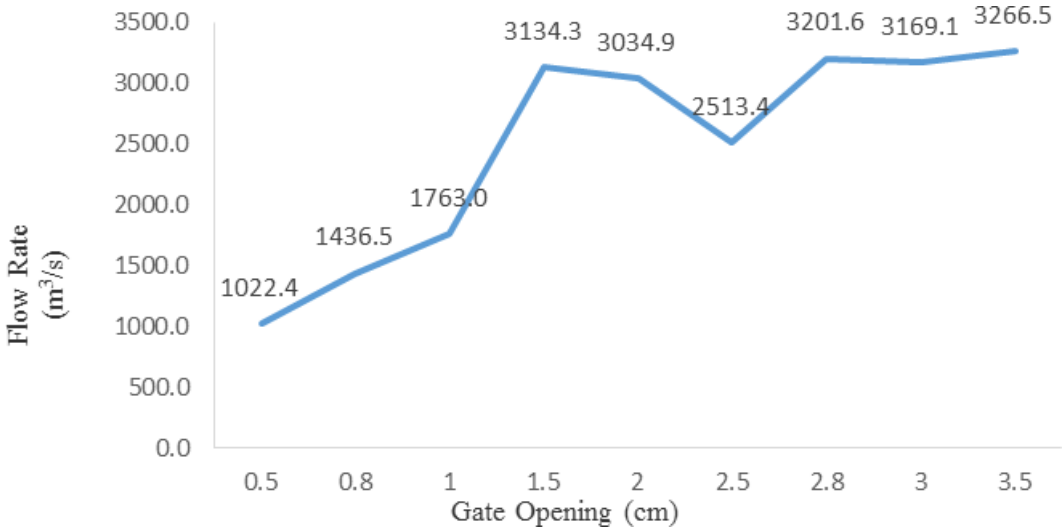


Figure 3.3 . Flow rate at several sluice gate opening

Figure 3.4 ndicate the flow velocity are changing from high velocity into lower velocity. High velocity occurs at the entrance and upstream area where it take place before hydraulic jump position. After the water flow detached from hydraulic jump area, it is entering the downstream area which has lower flow velocity.

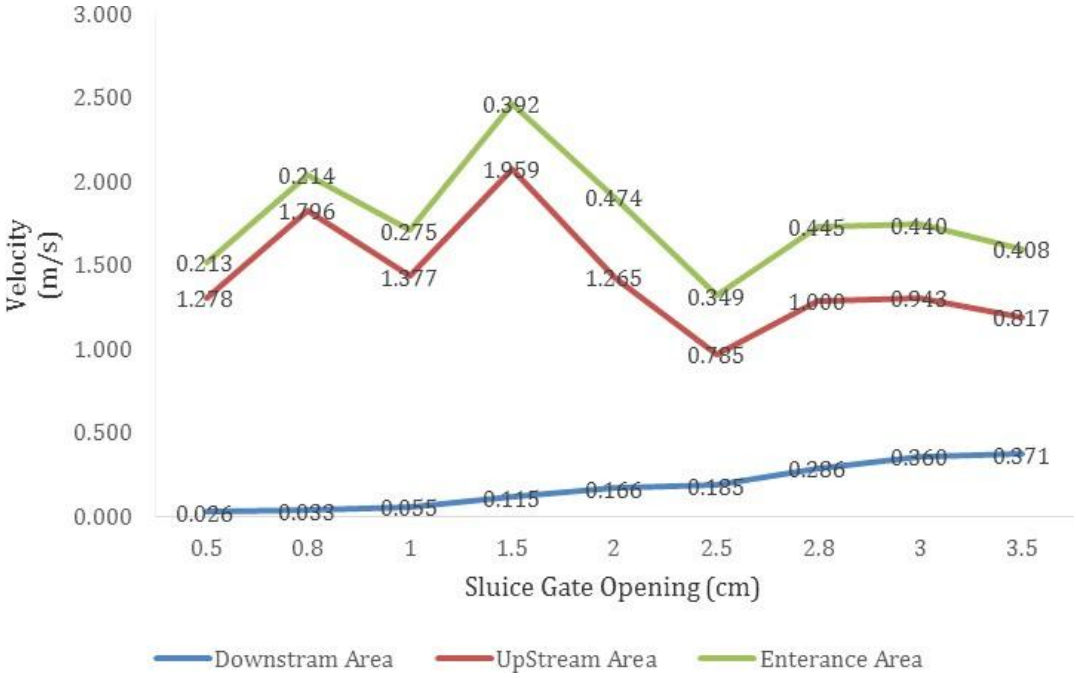


Figure 3.4 Velocity characteristic on each sluice gate opening

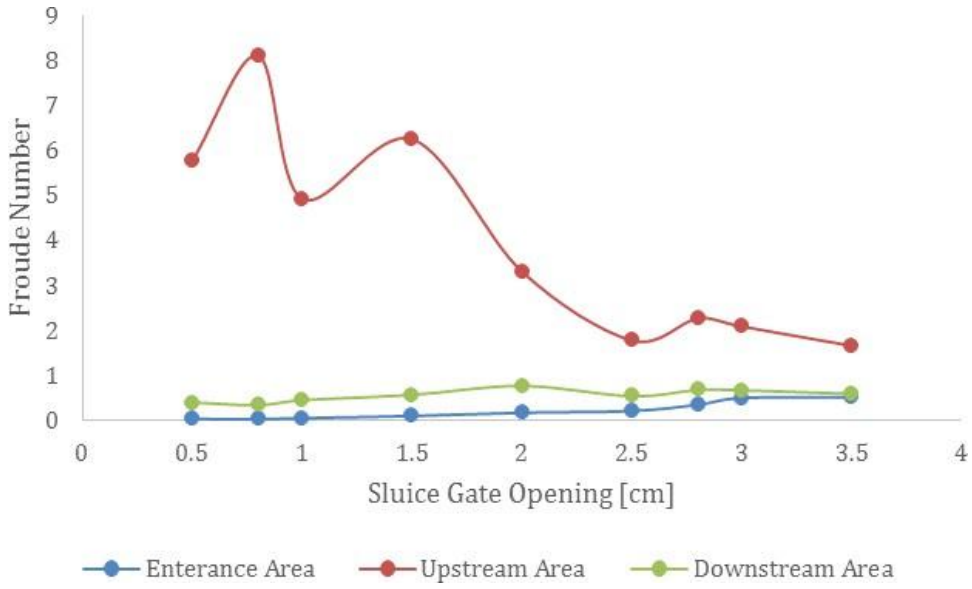


Figure 3.5 Froude Number Characteristic

Refer to the flow velocity and flow depth measurement, the Froude number can be calculated. The Froude number calculation for each gate opening are shown on figure 3.5. The Graphic shown that at the entrance area Fr < 1, which means the flow characteristic are subcritical flow. At the upstream area Froude Number Fr > 1 that indicate supercritical flow, otherwise at downstream area Fr < 1 which exhibit subcritical flow. This calculation result are confirming the theoretical of hydraulic jump phenomenon, wherein a sudden transition from a supercritical open channel flow regime to a subcritical flow motion.

4. Conclusion

A model of microcontroller irrigation base have been design as a prototype of automatic irrigation sluice gate. These prototype was successfully simulate the automatic sluice gate operation and describe the water flow characteristic in an open channel flow. By implemented this technology, it is expected to be able to optimize crop yields in the agricultural sector. Furthermore, it needs